

Identification of Hotspots and Safe Zones of Crime in Uttar Pradesh, India: Geo-spatial Analysis Approach

Jitendra Kumar¹, Sripati Mishra², Neeraj Tiwari³

¹Institute for Development & Research in Banking Technology (Established by Reserve Bank of India), Hyderabad-57, India

²Uttar Pradesh Police Services, Kanpur, India

³Department of Statistics, Kumaun University, SSJ Campus, Almora, India

¹jitendrakumar@idrbit.ac.in, ²shripati_123@yahoo.co.in, ³kumarn_amo@yahoo.com

Abstract-The crime is an act that an offence against the public and the perpetrator of that act are liable to legal punishment. It is closely associated with geographical and demographic variables. Present study aims to identify the area suffering major crimes named hotspot and the area with fewer crimes named safe zone with respect to different heads of crime against body. The data collected by State Crime Record Bureau, Uttar Pradesh, India are taken for study, and using the cluster analysis, the hotspots and safe zones of crime are identified.

Key words- Spatial Analysis; IPC; Crime Against Body; Cluster Analysis.

I. INTRODUCTION

The phenomenon of crime has been present in all ages and in all societies. It varies only in degrees and forms. There is no society without the problem of crimes or criminals. It is a perennial problem for the society. The concept of crime is essentially concerned with social order. It is well known that men's interests are best protected as members in the community. Crime is both normal and functional. No society can be completely exempt from it. Thus in every society, no matter in the past or in the present, man has experienced the evil of crime to a certain extent. It is also true that most of the people who are peace loving by nature believe in live and let-live principle, yet there are a few who, due to some reason or the other, deviate from the normal behavioral pattern and indulge into anti-social activities. If given a choice each one of us would prefer to live in a society where the rate of crime and delinquency is significantly low. But unfortunately that kind of peaceful atmosphere in society is not allowed to prevail, due to the inhuman activities of certain anti-social elements who constitute a small part of the population, but are much organized and hence, effective.

Donald (1956) described the American criminological concept and emphasized the treatment of criminals and Juvenile Delinquents. While discussing the personality aspect of the criminal, Donald (1956) laid down the emphasis on the effect of intelligence and its impact on crime causation. Paranjape (2001) advocated that criminology is a socio-legal subject and with the modern improvised techniques of handling criminals, a summarization of criminological findings for the students of this branch of knowledge has become all the more necessary. 'Crime in India' is the official publication of crime statistics of the country published by the National Crime Record Bureau, New Delhi working under the Ministry of Home Affairs, Government of India being published yearly. 'Crime in Uttar Pradesh' is the official publication of yearly crime data of the Uttar Pradesh published by the State Crime Record Bureau, Uttar Pradesh, Lucknow, India.

Greenburg and Rohe (1984) advocated the spatial analysis of crime data, mentioning that criminal activities in a spatial

context are certain environmental factors, such as the physical layout of an area, proximity to various services, and land use mixes - all of which are likely to influence criminal behavior. Crime Mapping Research Center at the National Institute of Justice categorized the hotspot detection and analysis methods and these techniques have been classified as follows: visual interpretation, choropleth mappings, grid cell analysis, spatial autocorrelation, and cluster analysis (Jefferis, 1998, 1999; Harries, 1999; Kulldorff, Huang, Konty, 2009). Earlier days the crime analysis explores possibilities of crime analysis based on the reported crime, but from the last few decayed the interpretation of crime in the form of map is more popular utilizing GIS information (Ratcliffe and McCullagh, 1999; Harries, 1999). Murray, McGuffog, Western, Mullins (2001) pointed out that the use of GIS information makes more valuable interpretation of study and also facilitate the identification of pattern with minimal efforts. William and Gedeon (2004) identified the safe and unsafe zone using principal component analysis and Discriminant analysis for the 100 USA cities considering general, social, and economic characteristics.

The Uttar Pradesh is diversified states in India in respect to social and income and the crime pattern also becomes complex. Present study aims to know the crime pattern of Uttar Pradesh, India crime under consideration of demographic and geographic areas. The district with more crime is named hotspot and district with less crime is named safe zone using cluster analysis by SaTScan and are represented in geographic map by ArcView. The data for all districts from the study are taken from the annual report of State Crime Record Bureau and they identified group of districts suffering more crime compared to rest of the district and scaled the area in crime behavior. The districts with less crime are selected as safe zone.

II. METHODOLOGY

As the face value of crime is the number of reported cases. It also refers the density that more population has more incidence of crime. The larger area gives more opportunity for crime. In the present study, we have the spatial analysis of Uttar Pradesh crime and identify the maximum crime zone as hotspot while less crime area as safe zone. The crime analysis is based on registered crimes as reported by Uttar Pradesh State Crime Record Bureau at district level. Whether it is hotspot or safe zone identified by SaTScan, the visualized presentation is made by ArcView.

The identification of hot and safe zone followed the spatial analysis used in the SaTScan software is described in detail by Kulldorff (1997) for the Bernoulli, Poisson etc models. The assumed distribution in the study is Poisson distribution; the scan statistic adjusts for the uneven geographical density of a

background population. For all models, the analyses are conditioned on the total number of cases observed. After identifying the safe and crime zone, the data are picturized to get better idea of Uttar Pradesh crime by ArcView.

III. CRIME DATA ANALYSIS

A. Murder

The scanning for cluster is done from high to low rates using the discrete poison distribution. Maharajgang, Sidarthnagar, Kushinagar, Sant Kabir Nagar, Ambedkar Nagar, Balrampur, Shravasti, Chandauli, Sant Ravidas Nagar, and Mirzapur are the districts with lesser crime rates so far as the reported murder cases are concerned. Whereas Gorakhpur, Varanasi etc. are the districts of very higher ranking in reported murder cases but all these districts have been found to be with the most likely clusters. This is just because crime rate ratio is related to the population and probably the area of the district.

Most of the densely populated district like Moradabad, Aligarh, Agra, Ghaziabad, Meerut, Lucknow, Kanpur Nagar etc. are estimated as secondary clusters, since the murder cases reported during the assessment year has been found not critical comparing ratio of the population of the district to the districts with most likely clusters.

Though the districts under police ranges in Meerut, Lucknow, Agra, Kanpur and Bareilly are worst effected so far concerning the number of reported cases of murder during the year 2008, yet the district under these ranges are bifurcated to be most likely and secondary clusters as given above.

The study shows that the number of cases in district as mentioned above is more and thus is denoted as worst affected districts or ranges, but when we see through population ratio we do not conclude the same. Similarly, considering the reported cases the least affected ranges are Mirzapur and Jhansi, but the study again concludes as what is revealed above.

The murder cases reported in the districts like Mirzapur, Sant Ravidas Nagar, Kaushambi, Sant Kabir Nagar, Sirdhath Nagar etc. are much less in number, whereas the cases reported in the districts namely Agra, Meerut, Lucknow and Kanpur Nagar are much more. Moreover, these districts have been placed in secondary cluster which clearly indicates that considering the ratio of the population of district with reference to crime reported, crime is less compared to the smaller districts like Mirzapur, Sant Ravidas Nagar etc. Districts thus under most likely cluster are required to be taken proper care of, so to reduce the number of murder cases.

B. Culpable Homicide not Amounting to Murder (CHNAM)

The most likely clusters are formed in the districts of Eastern and Central region of Uttar Pradesh including the major cities Faizabad, Gorakhpur, Varanasi, and Allahabad, and secondary clusters are found in 27 districts including major cities of Central and Western Uttar Pradesh of Aligarh, Agra, Lucknow, Kanpur Nagar, Bareilly, and Mathura etc. Most likely clusters and secondary clusters divide the state clearly into two regions. Only a few districts of Central region of Uttar Pradesh are common.

C. Attempt to Commit Murder

Major districts of Western and Central Uttar Pradesh namely Meerut, Ghaziabad, Muzaffar Nagar, Aligarh, Agra,

Mathura, Bareilly, and Badaun are falling under most likely cluster. 30 districts of Eastern Uttar Pradesh including major cities like Varanasi, Gorakhpur, Allahabad, Faizabad and Central Uttar Pradesh like Fatehpur, Pratapgarh etc. with Northern and Southern districts form secondary clusters. 9 districts are under safe zone. The crime recorded in 2008 has slightly diverted trend as compared to the crime of other years.

D. Dowry Death

There are 25 districts from Allahabad to Agra with some districts of Central Uttar Pradesh forms the most likely clusters and secondary clusters. from Varanasi to Ballia area wise, including North Eastern district of Balrampur, Shravasti and Basti etc. In 2008, it recorded the highest number of districts as safe zone among the crime data of the year 2005 to 2008.

E. Hurt/Grievous Hurt (HGH)

Most likely clusters comprise 7 districts of Western Uttar Pradesh, Meerut, Ghaziabad, Muzaffar Nagar, JP Nagar, and Bagpath with annual cases of 1.6. These districts are said to be reported with much less number of crime of Hurt/Grievous hurt thus are less affected. Secondary clusters comprising mainly Agra, Mathura, Aligarh and neighboring districts have the second highest reported annual cases of 11.4. The highest effected district is the Jaunpur with 11.5 average annual cases. Other secondary clusters including Bareilly and Moradabad districts have annual cases of 3.8 followed by Mahrajganj, Siddhartha Nagar, and Kushi Nagar with average annual cases of 3.3 followed by Balrampur with average annual cases of 1.3. Ballia, Ghazipur, Chandauli and Deoria have reported annual cases of 4.6. 14 districts of secondary clusters mainly Allahabad, Kanpur and Faizabad with neighboring districts have an average of 8.6 whereas Gorakhpur, Ambedkar Nagar and Sant Kabir Nagar have an average of 9.2. Jaunpur is most affected whereas the district Balrampur is least effected in the year 2008, 22 districts are observed as safe zone districts.

F. Kidnapping and Abduction

Most likely cluster includes 32 districts of Central and Western region of Uttar Pradesh whereas 31 districts of secondary clusters are found from mainly Eastern and partly Central Uttar Pradesh. Bareilly, Moradabad, Aligarh, Agra, Ghaziabad, Meerut, Mathura, Lucknow, and Kanpur Nagar are the major cities falling under the most likely cluster with an average annual case of 4.6 per annum. 31 districts are reflected in secondary cluster with an average of 1.9 average annual cases. Varanasi, Allahabad, Gorakhpur, Faizabad, Gonda and Basti etc. are the major districts along with smaller districts like Chandauli, Sonbhadra, Mirzapur, Hamirpur, Sultanpur, Balrampur, and Sant Ravidas Nagar Badohi etc.

G. Rape

Most likely cluster includes 19 districts of central and eastern region of Uttar Pradesh whereas 37 districts of secondary clusters are found from mainly western and partly Central Uttar Pradesh. Varanasi, Gorakhpur, Faizabad, Azamgarh etc. are the major districts along with smaller districts like Sant Kabir Nagar, Balrampur, Sant Ravidas Nagar Bhadohi and Shravasti etc. under the most likely cluster. Moradabad, Aligarh, Agra, Ghaziabad, Mathura, Lucknow, Kanpur Nagar, and Bareilly are the major districts along with smaller districts like Badaun, Fatehgarh, Banda, Etah, Unnao etc. are falling under the secondary clusters. Chitrakoot figured with little cases in the year. The average annual cases reported in the eastern region are less than half of the western region.

This infers that rape cases in Western Uttar Pradesh are almost two times more as compared to the eastern Uttar Pradesh.

H. Riots

Most likely cluster includes only one district of Lucknow with observed and expected cases ratio of 4.60. Secondary clusters include eight districts of western Uttar Pradesh with the ratio of observed and expected cases of 1.59 followed by third cluster of three districts of Allahabad, Pratapgarh and Kaushambi with ratio of 1.55. Ghazipur becomes the forth cluster with 121 cases registered against the expected cases of 79.56. Though the Lucknow has recorded the highest number of cases during year under observation yet most of the districts did not record the riot cases. Only 13 districts found affected during the year. 57 districts were found under safe zone during the year.

IV. PICTORIAL PRESENTATION OF HOT AND SAFE ZONE

The main object behind the current study is to identify the hotspot and safe zone in Uttar Pradesh, which will help policing activities. If the pattern of crime incidences is prior known, we can prevent the crime. The districts are in hot spot is required more police personal and specific strategy and safe zone can help to relax for the time being. The study performed discussed in last section using SatScan identified the districts in hot spot or safe zone, statistically evaluated by ratio of observed and expected (O/E), relative risk (RR) and Log likelihood ration (LLR) is given in appendix Tables 1-8. The hotspots and safe zones are presented in Figure-1 to Figure -8 given below:

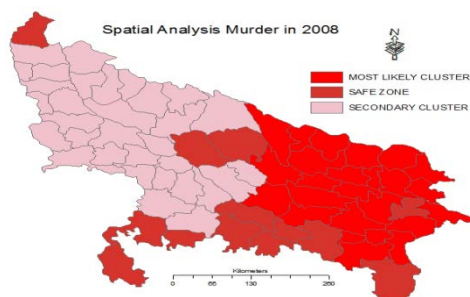


Figure 1

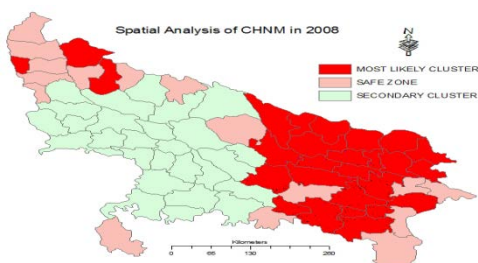


Figure 2

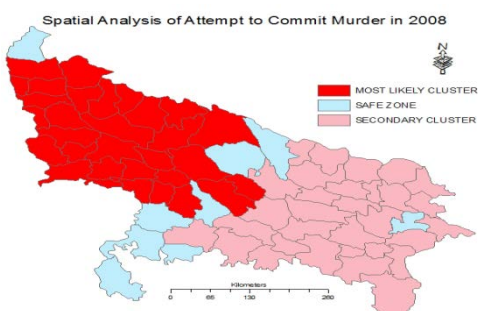


Figure 3

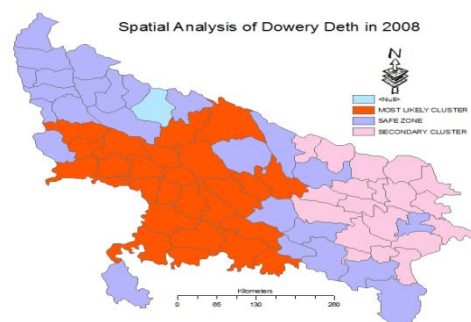


Figure 4

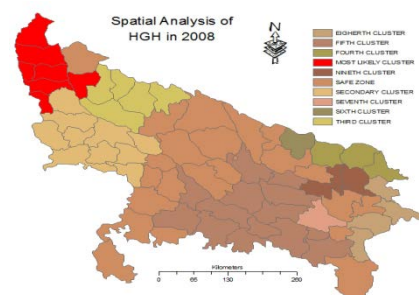


Figure 5

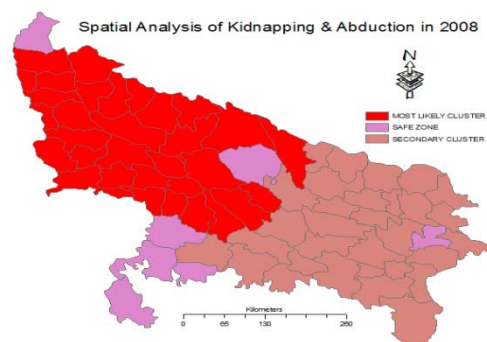


Figure 6

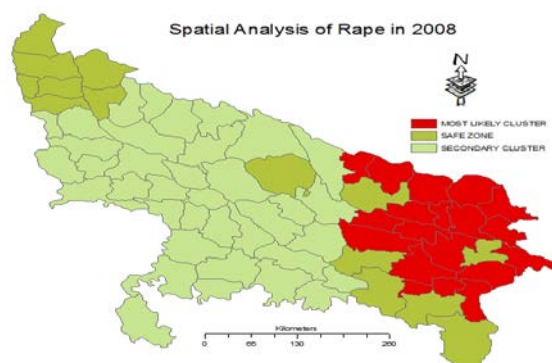


Figure 7

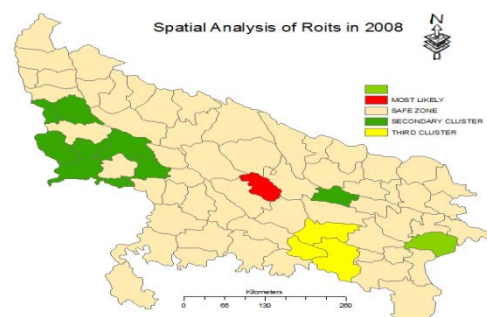


Figure 8

V. CONCLUSION

The crime pattern of eastern Uttar Pradesh has been estimated entirely different from the western Uttar Pradesh. The central Uttar Pradesh is mixed with either of the regions. The districts of eastern Uttar Pradesh record more crimes in murder, culpable homicides not amounting to murder and rape; and western Uttar Pradesh record more crimes like murder, hurt grievous hurt and kidnapping and abduction. As we know that culpable homicide not amounting to murder is the results of sudden provocation and the eastern Uttar Pradesh is comparatively a poor region of the state where sudden provocation and anger situation come on and off, the cases of CHNAM are more in the eastern Uttar Pradesh. The districts of the western Uttar Pradesh, namely Ghaziabad, Meerut, G.B. Nager, Muzaffarnagar along with Aligarh and Moradabad record the highest crime in the state. The districts of eastern Uttar Pradesh from Gorakhpur to Varanasi record lesser crime as compared to the western Uttar Pradesh. Allahabad, Lucknow, Bareilly, and neighboring districts are sometimes part of the western regions and sometimes the parts of the eastern regions.

APPENDIX

TABLE 1 CLUSTER INFORMATION FOR MURDER-2008

	Hot Spot	Sec- I
Population	63723786	79921469
No of cases.	976	2931
E cases.	1713.08	2148.52
A cases	1.5	3.7
O / E	0.57	1.36
RR	0.45	2.02
LLR	276.392600	271.927629

TABLE 2 CLUSTER INFORMATION FOR ATTEMPT TO COMMIT MURDER

	Hot Spot	Sec- I
Population	70069870	60488802
No of cases.	451	671
E cases.	614.78	530.72
A cases	0.6	1.1
O / E	0.73	1.26
RR	0.62	1.48
LLR	38.590812	27.948621

TABLE 3 CLUSTER INFORMATION FOR CHNAM

	Hot Spot	Sec- I
Population	74196567	74882897
No of cases.	2875	961
E cases.	1848.64	1865.74
A cases	3.9	1.3
O / E	1.56	0.52
RR	2.74	0.37
LLR	507.299726	422.422066

TABLE 4 CLUSTER INFORMATION FOR DOWRY DEATH

	Hot Spot	Sec- I
Population	54286765	47898881
No of cases.	1033	397
E cases.	717.51	633.08
A cases	1.9	0.8
O / E	1.44	0.63
RR	1.82	0.55
LLR	96.263342	67.393883

TABLE 5 (A) CLUSTER INFORMATION FOR GHG

	Hot Spot	Sec-I	Sec-II
Population	1.69e+7	2.27e+7	1.43e+7
No of cases.	277	2599	548
E cases.	1168.98	1563.83	989.33
A cases	1.6	11.4	3.8
O / E	0.24	1.66	0.55
RR	0.22	1.85	0.53
LLR	530	340E+2	1.27

TABLE 5 (B) CLUSTER INFORMATION FOR GHG

	Sec-III	Sec-IV	Sec-V
Population	7.25e+6	3.37e+7	1.71e+6
No of cases.	241	2898	23
E cases.	500.08	2324.30	117.93
A cases	3.3	8.6	1.3
O / E	0.48	1.25	0.2
RR	0.47	1.33	0.19
LLR	86.1	83.6	57.7

TABLE 5 (C) CLUSTER INFORMATION FOR GHG

	Sec-V I	Sec-VII	Sec-VIII
Population	3.97e+6	1.03e+7	7.34e+6
No of cases.	457	478	677
E cases.	273.97	712.91	506.06
A cases	11.5	4.6	9.2
O / E	1.67	0.67	1.36
RR	1.70	0.66	1.36
LLR	52.3	46.3	27.4

TABLE 6 CLUSTER INFORMATION FOR KIDNAPPING AND ABDUCTION

	Hot Spot	Sec-I
Population	80877749	74882897
No of cases.	3688	1413
E cases.	2588.53	2396.66
A cases	4.6	1.9
O / E	1.42	0.59
RR	2.33	0.44
LLR	454.528707	382.253305

TABLE 7 CLUSTER INFORMATION FOR RAPE

	Hot Spot	Sec-I
Population	47898881	82595289
No of cases.	275	1171
E cases.	528.93	912.07
A cases	0.6	1.4
O / E	0.52	1.28
RR	0.44	1.76
LLR	96.726585	72.400039

TABLE 8 CLUSTER INFORMATION FOR ROITS

	Hot Spot	Sec- I	Sec- II	Sec- III
Population	3730412	17915907	9122581	3092651
No of cases.	441	735	363	121
E cases.	95.96	460.89	234.68	79.56
A cases	11.8	4.1	4.0	3.9
O / E	4.60	1.59	1.55	1.52
RR	5.00	1.72	1.60	1.54
LLR	341.891858	78.810646	32.034445	9.495270

ACKNOWLEDGEMENT

First author gratefully acknowledge the CST, Uttar Pradesh and SHIATS, Allahabad for Young Scientist visiting fellowship under which the work is carried out.

REFERENCES

- [1] Donald R Taft, 1956. Criminology, 3rd edition, New York, NY, Macmillan.
- [2] Greenburg, S. and W. Rohe, 1984). Neighborhood Design and Crime. Journal of the American Planning Association. 50: 48-61.
- [3] Harries, K., 1999. Mapping Crime: Principle and Practice. Washington DC: National Institute of Justice (NCJ 178919).
- [4] Jefferis, E. 1998. A Multi-Method Exploration of Crime Hot Spots. Paper presented at 1998 Academy of Criminal Justice Sciences (ACJS) Annual Conference. URL: www.ojp.usdoj.gov/cmrc/whatsnew/hotspot/intr o.pdf.

- [5] Jefferis, E., 1999. A Multi-method Exploration of Crime Hot Spot: A Summary of Findings. Washington DC: U.S. Department of Justice, Office of Justice Program, National Institute of Justice, Crime Mapping Research Center.
- [6] Kulldorff, M., 1997. A spatial scan statistic. *Communs in Statistics-Theory and Methods*, 15: 1481-1496.
- [7] Kulldorff M, Huang L, Konty K. A., 2009. Scan statistic for continuous data based on the normal probability model. *International Journal of Health Geographics*. 8:58.
- [8] Murray, A.T., I. McGuffog, J.S. Western, and P. Mullins, 2001. Exploratory spatial data analysis techniques for examining urban crime. *British Journal of Criminology*. 41: 309-329.
- [9] Paranjape N V., 2001. *Criminology and Penology*, 2nd edition, Central Law Publication, Allahabad, Uttar Pradesh.
- [10] Ratcliffe, J.H. and M.J. McCullagh, 1999. Hotbeds of crime and the search for spatial accuracy. *Journal of Geographical Systems*. 1: 385-398.
- [11] William K and Gedeon R., 2004. A Multivariate Statistical Analysis of crime rate in US Cities URL: <http://www.users.muohio.edu/porterbm/sumj/2004/CrimeStats.pdf>.



Dr. Jitendra Kumar was born in Hamirpur, Uttar Pradesh, India and obtained masters in Statistics and Doctoral Degree from Department of Statistics, University of Allahabad in 2005 his interest of research areas are Bayesian time series, Geo Information System, Design of Experiment, Business process Reengineering and Big Data.

Dr Kumar has more than ten years teaching and research experience and publishes papers in theory and application statistics in different journals published in India and abroad, like *Statistics & Probability Letters*, *American Journal of Mathematical & Management Sciences* and *Indian Journal of Economic and Business*. Presently Dr Kumar is working as Assistant Professor at Institute for Development & Research in Banking Technology (Established by Reserve Bank of India), Hyderabad-57, India since august 2011, earlier he was working as Assistant Professor in Sam Higginbottom Institute of Agriculture, Technology & Sciences, Allahabad, Uttar Pradesh, India. He was awarded Young Scientist visiting fellowship by Council of Science & Technology, Government of Uttar Pradesh in the year 2011 and received the travel fellowship by CSIR, DST, INSA and MOSPI to participate conferences and meeting at USA, CHINA and UK.



Dr Sripati Mishra is Master in Statistics from Kanpur University in 1984 and Ph D Degree from Sam Higginbottom Institute of Agriculture, Technology & Sciences, Allahabad, Uttar Pradesh India in 2011. His area of interest are criminology, human rights and rural administration, Spatial analysis of crime and predictions.

Dr Misra has a vast experience of supervision of investigation of criminal cases resulting an exhaustive knowledge of pattern of criminal behaviour and criminological trends. He is currently

working as Additional Supritendent of Police in Uttar Pradesh, India. He wrote three books and and article in different police magazines and other journal.



Dr. Neeraj Tiwari is working as Professor & Head in the Department of Statistics, Kumaun University, S.S.J.Campus, Almora, Uttarakhand, India. He obtained his M.Sc. and Ph.D. degree in Mathematical Statistics from Lucknow University, Lucknow, India. He has an experience of more than 21 years in research and teaching.

Professor Tiwari has published more than 30 research papers in various international journals and guided 10 students for their Ph.D. degree in Statistics. He has written two books and other than that also edited a book He has completed three major projects under University Grant Commission, Indian Council of Medical Research and Uttarakhand Council of Science and Technology. He has attended more than 20 international conferences in India, U.S.A., China and Czech Republic. He is actively engaged in the editorial board of different national and international journals and reviewed research papers for different journals such as *Communications in Statistics-Theory and Methods*, *American Journal of Mathematical and Management Sciences*, *Environmental and Ecological Statistics*, *International Journal of Health Geographics*, *Journal of Indian Society of Agricultural Statistics*, *Journal of Indian Statistical Association*, etc. He has organized one National Seminar, one UGC Refresher Course, Popular Science Lectures in the department. He has delivered invited lectures/talks in various reputed institutions in India such as Indian Statistical Institute Kolkata, Indian Society of Agricultural Statistics New Delhi, Allahabad University, Garhwal University, etc.